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Submitted in partial fulfillment of
the requirements for the degree of

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ABSTRACT

The roll-on-roll-off and lift-on-lift-off cargo handling concepts have developed rapidly in the transportation field since the early 1950's. The utilization of these two concepts has revolutionized the transportation industry. Based on the information available and the comparative analysis made it can be seen that the economical advantages of the lift-on-lift-off operation are more applicable to commercial transportation, whereas the fast turn-around features of the roll-on-roll-off operation are of particular importance in the logistics field for successful support of Military operations

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CHAPTER I

INTRODUCTION

The purpose of this comparative analysis of the roll-on-roll-off versus the lift-on-lift-off vessels is to (1) indicate what each operation consists of; (2) compare both operations on a cost basis; (3) indicate which operation is preferred and why by both military and commercial transportation experts; and (4) indicate where both operations can be utilized to the greatest advantage to improve the overall performance of transportation of cargoes from one point to another.

To fully comprehend the above mentioned operations one must first realize what brought about these new transportation developments---which still in their infancy-- have sparked a revolution which might culminate in a genuine renaissance in all areas of the transportation industry. First of all, the concept of containers and the idea of containerization is by no means new. Historically, this principle was recorded by Dr. James Anderson, an Englishmab, in 1801. Interest in containerization is recorded in countless volumes of literature and periodicals wherein many speak of the growing interest in the field of containerized transport and the ultimate big advantages to the shipper. However, much of this

interest resulted in nothing more than a plan or sketch of how the project would work and few plans were ever carried to the point of actual service.

Even before the 1930's, international interest in containers was growing. Interchanging containers between countries required standardization at the international level, and an International Container Committee was formed in September 1928. The International Container Bureau succeeded the Committee under the auspices of the International Chamber of Commerce.

Although studies and tests were completed leading to proposals for several types of containers for international traffics, World War II intervened before extensive applications could be established. However, following the war several European container movements were quickly re-established; and as a result, Europe was, and is to this day, several years ahead of the United States in the concept of containerized freight.

Before, during, and after the war, various United States piggyback trailer services [1] were in operation but only to a limited degree. Finally in 1953, this

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[1] Piggyback trailer service consist primarily of placing a vehicle of trailer truck dimension on a railroad flat car and moving it from one point to another via rail. Upon arrival at the railroad destination, the trailer truck is then driven off the flat car and on to delivery point.

fright service began to achieve volume and has grown steadily ever since. This service was, in fact, the fore runner of the containerization techniques as used by the transportation industry today.

The same standardization problems that existed in the 30's still exist today and this is perhaps the biggest reason that there are problems between the various segments of the transportation industry. Great interest in this area renews hope in the minds of the shipper and the economics available to him. Yet the lack of standards for size, lifting mechanisms, and other appurtenances continue to stall full acceptance on a wide scale. Similarly, the questions of tariffs, interchange between carriers, load restructions, and ownership of units block further acceptance of the concept. Regardless of the questions raised, transportation experts are working on the concept from every conceivable approach and because of this, containerization is well on its way to being an established fact of life in the transportation field.

While the concept of containerization was being used in gradual stages, no throught was given to the improvement of the movement of vehicles from one continent to another except by the standard sling type lift-on-lift-off methods into the cargo hold of a ship for water transportation. With the advent of World

War II all of this was changed and military commanders were forced to stop and take a second look at the methods used to transport their motorized vehicles. The military knew they could load their combat vehicles in the United States without too much trouble but the immediate problem facing them was one of off-loading them at their destination in a minimum of time. Not only did they want to get these vehicles to the battlefield as quickly as possible, but also they wanted to make short turn around time in order to minimize the dangers of suffering an enemy aerial attack while in port.

With typical American initiative, a joint industrial-military effort was made and commercial Sea Train vessels were converted into transports for military vehicles. These vessles had been designed originally to haul railroad freight cars on inter-coastal service along the shores of the continental United States. The military, after driving tracked and wheeled vehicles onto these ships, then transported them around the Cape of Good Hope and eventually drove them off in the vicinity of the Suez Canal. These successful moves credited the United States with a big assit in the eventual defeat of Rommel in Africa. The next use of the converted Sea Train vessels was to get armored vehicles into Morocco in support of General Patten's invasion forces. Both of these incidences and many more, at least from the military point of view, emphasized the use of a roll-on-roll-off vessel.

The military need for this type of transportation increased after the war. In fact it has been determined that movement of wheeled and tracked vehicles constitutes:[2]

1. Approximately 85% of all deployment tonnage when a unit moves overseas.
2. Approximately 25% of all resupply tonnage.
3. Approximately 25% of all peacetime tonnage.

In view of the above and the fact that during an invasion port facilities will undoubtedly by destroyed or be non-existent, the Army transportation authorities gave certian requirements to the Military Sea Transportation Service to develop a transportation system which would produce the following results:

1. Use a minimum of personnel.
2. Reduce supply cycle time.
3. Thinner, faster pipeline requiring less stockage overseas and within continental United States.
4. Reduce vulnerability in terminal areas to include shorter turn-around time and faster cargo clearance.
5. Simpler, cleaner documentation.

Due to the high percentage of wheeled and tracked type vehicles to be shipped both in peace and war, it was felt there was a need for a type of vessel which would allow for rolling vehicles on to a ship and rolling them off at given destinations. A giant step was taken when the USNS COMET was launched in 1957. This ship was the result of a multiple effort by the

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[2] Colonel Ransome T. Looper, USA, "Will Sealift Go RO/RO?", Armed Forces Management, October, 1963.

Military Sea Transportation Service, Maritime Administration, private industry and Army transportation authorities. The COMET, designed to lift one-sixth of an armored division, is capable of rapidly leading and discharging its cargo of vehicles under their own power. Including some 700 units composed of tanks, trucks, jeeps and gun mounts in its one-sixth armored division slice, the COMET is quickly loaded through its four side ports and one stern ramp. Also, its two cargo holds, compatible for CONEX[3] utilization, can be rapidly loaded or unloaded with its own cargo gear. It does not require either floating or dock-side assistance. In addition to the fast loading and unloading feature which allows for almost incredibly short turn-around time, the ship offers a means of lifting cargo without breaking bulk.

The Army feels that the COMET has established its mobilization potential and more than adequately fills their needs. Commercial transportation experts have remained for the most part skeptical concerning the adoption of this type of wessel for commercial use. In 1955 the McLean Trucking Company became interested in the idea of roll-on-roll-off for the movement of trucks by water but after experimentation

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[3]CONEX is the name of container used by the Army.

found that the operation was not as economical as the lift-on-lift-off operation in conjunction with containerized ships. They believed that the shipping public would benefit from the economies of low cost transportation coupled with the flexibility of modern door to door motor freight service.

Thus with the boom in containerization's lift-on-lift-off and the Army's and the truckings' segment of the industry interested in roll-on-roll-off, we can definitely see the revolution that is taking place within the transportation industry today.

CHAPTER II

CONTAINERIZATION

Before an intelligent discussion of the pros and cons of roll-on-roll-off and lift-on-lift-off can be made, it is first important to understand what is meant by containerization and the problems its innovation faces. The term containerization perhaps already qualifies as a word of art in transportation parlance, like wharfage of FOB (freight on board). Its meaning, however, is neither so well understood nor so precise as that of most terms that have found their way into the lexicon of transportation terminology.

Containerization, viewed as a working tool of transportation-as an integral part of the transportation process--contemplates the movement of goods from the shipper's door to the receiver's place of delivery in a packing box which is integrated into the transportation system. The packing box may consit of a conventional highway trailer, with wheels attached or demountable, or it may be a container of another sort designed so that it can readily be secured to a chassis or flatcar or lifted or rolled aboard a ship or other media of transportation.

Containerized transportation has an almost limitless range. In its simplest form, it may be provided by

a single carrier, confined to points on its own line or route. For example, a railroad might elect to transport its freight in trailers or containers mounted on flatcars in lieu of the conventional boxcar. The trailers or containers would be sent to the shipper's door for loading and delivered at the platform of the receiver without rehandling of the goods. According to the best estimates currently available, there will be between 0.8 and 1.5 million containers in use by 1970,[1] directly competing with present conventional practices in the rail, water, motor and air transport industries.

If perfected and advanced to the ultimate extent of its potential usefulness, containerization could afford the basis for completely integrated, world wide door to door transportation, in all purpose, readily interchangeable equipment acceptable to substantially all types of cargo, thus forming a transit pipeline by all modes of transport--rail, highway, water, and air, separately or in any combination.

Progress in containerization in the last few years has been truly phenomenal, but, over-all, the concept is still in the experimental stage, and formidable problems remain to be solved. The subject should be viewed in proper perspective. Any analysis of

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[1] Harry E. Holmes, "Containerization", National Defense Transportation Journal, March-April, 1961.

progress in containerization is likely to start with technical description of the plans (to be discussed later) which have been put into actual use and to project its future along those horizons. The subject of containers must also be appraised from the point of view of the economics involved and standardization of the cargo units.

Transportation companies find econimic advantages in containerization through:[2]

1. Lower freight rates.
2. Lower handling cost.
3. Lower in transit insurance costs.
4. Reduction of product damage in transit.
5. Reduction of •limination of pilferage during shipment.
6. Recuction of traffic problems.
7. Reduction of warehousing problems.

Based on the above, shippers have been very interested in using containers and the associated transportation for movement of their cargoes.

Lower freight rates are possible because the cheaper methods of transportation can be utilized in the moving of containerized cargoes. Savings may be partly or fully offset by necessitating the return of empty units. Thus careful cargo recruitment is required to overcome this possibility. By using a containerized shipment the handling requirements are materially reduced and the ever present potential for pilferage is

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[2] Harry E. Holmes, "Containerization", National Defense Transportation Journal, March-April, 1961

effectively eliminated. Similarly, savings realized by ship operators from a faster turn-around are substantial. The reduction in damaged cargoes along with the other aspects discussed substantially assist in reducing the cost of transporting cargo and this saving is in turn passed on to the shipper through lower freight rates.

As demands for capital to operate business have grown, many managers have reduced investment in inventory and warehousing. In many cases companies who are able to transport goods in a shorter period of time can reduce inventory. In addition, saving are possible through elimination of warehousing space. For many companies distribution from a single warehouse is limited to a short distance because of slow loading and unloading of trucks and trailers. The use of containers allows for quicker and more frequent deliveries from primary warehouse centers to secondary distribution points. At some secondary distribution points, warehouses may be eliminated by having delivery trucks pick up an entire container and deliver to individual stores directly from the container.

The problems of standardization have been seriously studied for a long time but somehow the studies never got past the drawing board stage until, in the fall of 1958, a crash program was mounted by the National

Defense Transportation Association and the subject was placed in the hands of a Special Subcommittee on Containerization and Standarization. The subcommittee was made up of industry, transport, and government executives and experts and in less than a year they came up with recommended basic dimensional standards for containers which are now widely accepted. The recommendation was for containers of 20 and 40 feet lengths, or other lengths of which 40 is a multiple, for use singly or in tandem, with 8 by 8 foot height and width dimensions.[3] In conjunction with this recommendation, the Maritime Commission is attempting to standardize ship construction to afford size accomodations for the 40 foot box and division thereof. All of these efforts may prevail in a standardization compatibility available for all modes of transportation by late 1965. Table I indicates the characteristics of typical containers that are in use today.

Of course, many people said that these standards were not workable, citing a variety of reasons and special situations. It was said that even if adopted for use in this country, such standards could not be made applicable in Europe because of clearances and for other reasons. Nevertheless, the report was the spark

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[3]Ibid., p. 31.

TABLE I

CHARACTERISTICS OF TYPICAL CONTAINERS*

Company	Material	L	X W	X H
Alaska S. S. Co.	Steel	6' 5"	4' 3"	6' 10"
Alaska S. S. Co.	Steel	12' 3"	8'	7'
Alaska S. S. Co.	Aluminum	40'	8'	12' 10"
U.S. Military (Conex)	Steel	8' 6"	6' 3"	6' 10"
Baltimore & Ohio R.R.	Steel	36'	8'	8'
BullLine	Steel	7' 9"	6' 5"	6' 9"
BullLine	Steel	15'	8'	7' 6"
BullLine	Aluminum	35'	8'	8'
Container Transport Int'l.	Steel	16'	7'	7'
Grace Line	Aluminum	17'	8'	8'
Matson Navigation Co.	Aluminum	24'	8'	8' 6"
Sea-Land Service Inc.	Aluminum	35'	8'	8'
Erie & St. Lawrence Corp.	Aluminum	8' 6"	8'	8'
New York Central	Aluminum	35'	8'	8'
New York Central	Aluminum	36'	8'	8'
New York Central	Aluminum	40'	8'	8'
United Cargo Corp.	Aluminum	10' 6"	7' 6"	7' 4"

* Source: Harry E. Holmes, Industrial Research Analysist, Reynolds Metals Company.

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]

[illegible]

that lit the tinder and despite all objections, orders for containers of the specified sizes began to flood the manufactures. Then, in May 1962, the news came from London that the community of European nations, acting through the International Organization for Standardization, had tentatively agreed upon standard 10 and 20 foot containers with cross section of 8 feet. These are the American standards except that they do not extend to the maximum length of 40 feet.

Thus the essential break through on the size of containers abd so the implementation on a national and a global basis is at hand. There is a world-wide consciousness of the importance of standard, interchangeable transport equiment to the economy and the safety of free nations everywhere. The sucess of the venture in this country is being closely watched and acceptance of the concept on an international basis will hinge on the vigor and intelligence of United States leadership.

A prototype of the all-purpose container was unveiled at the annual convention of the National Defense Transportation Association in Seattle in the fall of 1959. The 40 foot container displayed could carry automobiles on retractable ramps, liquid cargo in collapsible rubber tanks, or dry cargo when the tanks were removed and the ramps folded against the floor and ceiling. It was capable of being insulated and refrigerated.

Since that time, dual-purpose containers have been manufactured and put into practical use between the eastern and western seaboards, hauling dry cargo westbound and refrigerated cargo eastbound. The techniques of refrigeration and insulation have been so perfected that only an insignificant amount of cubic capacity is sacrificed to produce this equipment which practically doubles the productive capacity of each container. Similar equipment is being used in certain land-sea operations.

As of 1959, there were approximately 125,000 general cargo size containers in existence. Of these, approximately 80,000 were the CONEX type used by the military. The remaining 45,000 units[4] were distributed about as follows:[5]

1.	Marine carriers	20,000
2.	Railroads	18,000
3.	Private shipper and common motor carrier	5,000

Of the 5,000, private shippers represented, by far, the major share. Very few were owned by common motor carriers.

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[4]Harry E. Holmes, Containerization", National Defense Transportation Journal, May-June, 1961.

[5]Ibid., p. 54.

FIGURE 1

The total van containers for the same date was about 12,000-15,000 units. Approximately 10,000-12,000 of these units were in marine service, while the remaining 2,000-3,000 units were divided as follows:[6]

1.	Railroads	1,000-2,000
2.	Motor carriers	about 1,000 units or less

In the future it was believed the cargo-sized unit will develop a volume potential of 6000,000 units or more by 1970. The corresponding year estimate for van-size containers would be in the area of 300,000 units or more.[7]

An exploration of the two sets of forecast figures show that during 1958 there were approximately 2,300 general cargo merchant vessels under United States control. About 600 of these were active vessels. Most of these ships fell into Victory, Liberty, C1-A, C1-B, C-2 and C-3 types.[8] Each one of these vessel types are capable of carrying within the hatch square areas between 119-218 cargo containers. Because of the types of cargo handled and the differences in inter-port distance, it cannot be assumed that each one of the available vessels will containerize all of their cargo capacity. However, with most of the major steamship companies actively

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[6] Ibid., p. 55
[7] Ibid.
[8] Ibid.

pursuing container programs, it is possible that a considerably greater number of container units will be required in the near future than are already in use.

In any system of containerization for shipboard use, there would necessarily have to be two containers off board for each container on board. This comes from having one container at Port A and another container at Port B for a return trip. As the number of ports are increased, additional container units will be required in the system to maintain the service.

Not all of the ships currently in the United States merchant fleet can be expected to carry cargo-size container units, as many will be converted to or replaced with "cell" type van container vessels. Most of the experts believe that between 10-20 percent of the active United States fleet will become van container operations in the next ten years, thereby inducing the cargo-size container demand to about 540 ships. The number of container units carried by a container ship will vary and depend, to a great deal, on the size and design of the ship, cargo volume at each port of call, and the types of cargoes carried. Some operators will containerize only one hold of a ship while others will completely containerize vessels with all holds designed for "cell" cargoes. Likewise other vessels load container cargo only on deck. Because of this variation, the projection

forecasts are based on 250 van units per ship.

The current container unit and equipment cost are a substantial part of the evaluation of any containerization movement. A box, 8' by 8' cross section and 20' in length, costs in steel approximately $1,500; in aluminum $2,000; and plastic, somewhere around &6,000.[9] However, the cost figure for a box is only part of the total container cost. It must be evaluated in terms of or in relationship to railroad boxcars and highway trailers. The Interstate Commerce Commission reports the average boxcar price at about $9,000, while the highway trailer will cost somewhere around $4,500 complete. In order to truly compare the container to these other two transportation units, an initial container cost of approximately $3,500 for a set of wheels must be added. Thus, the total container cost for replacing the highway trailer is at least $5,000. This gives a competitive price advantage to the highway trailer of about $1,000. On the other hand, one set of wheels or bogies is not always required for each container unit. This will depend on the requirements of the service and the desires of the user.

If the container potential is to be realized, a container unit plus wheels must be at a cost figure closer to the present highway trailer cost. To offset

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[9]Ibid., p. 53

the differences in costs, Reynolds Metal Company's product development division worked with shippers and container manufacturers in the design of a unique aluminum container that snap-locks together eliminating welding and riveting required in conventional containers. It is hoped that this will reduce the cost of the containers and storage space requirements for empty returns.

Another problem facing the container concept is that containerized freight usually requires the use of more than one carrier system. Some degree of cooperation and equitable distribution of the cost savings among the carriers is needed. The absence of integrated or coordinated carrier systems and the historic competition amoung them had retarded the growth of containerized freight. In recent years there has been more cooperation, exchange and utilization of each others services in the railroad-trucking industries. There has been several shipping companies that have expanded their operations into the van trailer area of transportation, while at the same time, there has been a combining of trucking and shipping through the use of containerization. The economies of containerization are a great force in favor of cooperation and coordination because carrier management and shippers are looking for more economical freight movement. The shippers have long waited and strived for a movement embodying the single carrier system and now this is slowly coming true.

Mr. Waldemar Isbrandtsen, Vice President of Isbrandtsen Company, told assembled members of the American Association of Port Authorities in May 1961 that:

> Containerization and coordination of the transportation industry are probably the only things that could save the American steamship industry from the competition of foreign flag lines and from the rising costs of transporting goods across the seas.[10]

To do this he said that shipping companies must become "doers" and not just "talkers" and take their example from such companies as Matson, Grace Line, McLean, Erie and St. Lawrence. He further pointed out that each of these companies developed a container particularly suited to their ports of call. Mr. Isbrandtsen further advocated the breakdown of the respective trade routes into small circles with one steamship line carrying containers one way and another line carrying them the other way so that both lines could hit the most efficient six-day turn around average. The Maritime Administration has attempted to help steamship companies apply the two concepts that Mr. Isbrandtsen had advocated, but not with the success that had initially been hoped for.

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[10] Waldemar Isbrandtsen, "Can Containerization Save the U.S. Shipping Industry", National Defense Transportation Journal, May-June, 1961

Every day new concepts and techniques for handling and moving cargoes are being pioneered. Among the many up and coming innovations in containerization, are the Flexi-Van 5-wheeled "yard boss" tractor which single handedly moves containers on and off their special rail cars; the big container carrying vessels of Grace Lines and Sea-Land Service; Seatrain Lines' massive crane which places containers or railroad cars aboard ship; and Fruehauf "twin-twenties", 20 foot long containers which can be used singly or in combination to form one 40 foot unit.[11] Based on these innovations, it can be seen that emphasis is being placed on containerized cargo by the transportation industry.

The one thing that stands out above all others is that containerization is not just a physical contraption. It is a concept that has already begun to change the shape of the transportation industry in an era of rapidly changing technology. Its real advantages are meaningless to the shipper unless they are translated in a realistic price. The essential bridge between the producer and the consumer of transportation is the freight rate and this is what the transportation industry hopes will make the "bridge".

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[11] "Camera On Cargo", Via Port of New York, March, 1965.

CHAPTER III

THE ROLL-ON-ROLL-OFF CONCEPT

As was mention previously, the Department of Defense has long recongized a need for a specially designed vessel suitable for carrying wheeled and tracked vehicles. World War II showed the need for this type of vessel and based on this, the Army, through the Bureau of Ships, engaged George G. Sharp, Incorporated to develop the design and prepare the contract plans and specifications for a roll-on-roll-off type ship. The ship was to be equipped and designed so as to provide rapid loading and discharging of vehicles under their own power to and from piers, lighters and landing crafts. As a secondary task, the vessel was to be capable of transporting general cargo handled by conventional means.

The basic idea in a vehicle cargo ship is that the vehicles can roll-on or roll-off the ship under their own power through side and/or end ports and go to various decks within the ship by means of ramps, which due to their width and small incline constitute normal roadways. From a standpoint of vehicle stowage and maneuverability, long rectangular holds are obviously preferable. The length of the holds presented a key

problem because of two contradictory requirements. On one hand, the length of ramps resulting from the limiting slope and required headroom, in conjunction with the vehicle turning radius, required a minimum hold length of 130 feet. On the other hand, the ship was required to be at least a one compartment ship from the standpoint of flooding and damaged stability. Another problem resulting from the design requirements was one of structual integrity of the strength of the decks since large hatch openings were needed for efficient handling of general cargo, and at the same time, large cuts had to be made for the vehicle ramps.

George G. Sharp, Incorporated, prepared studies in which a series of designs were analyzed for floodingable length, capacity vehicle handling and efficiency as cargo carriers. These designs were radically different, one from the other, except for length, beam, draft and speed which were established by the Navy. The design recommended and chosen by representatives of the Military Sea Transportation Service, Bureau of Ships and Army Transportation Corps were characterized by the following features;[1]

1. Machinery midships.
2. All of the crew housed in one midship house.

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[1] Lorentz Hansen, "Roll-On-Off Prototype for MSTS", <u>The Log</u>, January, 1955.

3. Two 130 foot long vehicle holds, one forward and one aft of the machinery space, and two small general cargo holds forward.
4. Fixed main ramps of 14 degree slope, located in the center of the ship above and through the machinery space.
5. Two-compartment subdivision to the main deck, both in vehicle condition and general cargo condition and one-compartment subdivision to the second deck.
6. Two effective strength decks without major cuts outboard of the girder line.
7. Ten cargo handling gangs.
8. Ramp arrangement allowing all decks including weather decks to be loaded through side and stern ports.

It was considered that this design would result in a ship that would successfully accomplish the objectives of MSTS., carrying a large number and variety of military vehicles at a good speed, capable of using secondary ports and of loading and discharging within a day, independent of shore cargo handling facilities and labor. Although this specific design was not directly applicable to commercial operations, it clearly demonstrated the potentialities of the basic roll-on-roll-off principle as a means of solving the paramount shipping problem of cargo handling cost and long in-port time.

Based on the above characteristics, the USNS COMET (T-AK 269) was launched on 31 July 1957. She was built for the Navy's Military Sea Transportation Service by the Sun Shipbuilding and Dry Dock Company. Her building was supervised by the Maritime Administration and she was the first of her kind to be specifically designed and constructed from the keel up as a roll-on-

roll-off vehicle cargo ship. The following are the COMET's charcteristics.[2]

1.	Keel Laid	15 May 1956
2.	Launched	31 July 1957
3.	Length overall	499 feet
4.	Length between perpendiculars	465 feet
5.	Beam	78 feet
6.	Design draft	22 feet
7.	Deadweight (on 22' draft)	5,990 feet
8.	Deadweight (on 27' draft)	10,111tons
9.	Normal Shaft H.P. (twin screw)	12,000
10.	Maximum continuous shaft H.P.	13,000
11.	Speed	18 Knots
12.	Crew accommodations (officers, men, four spares)	73
13.	Ship's complement:	
	Officers	16
	Men	40

The operation of the COMET is simple. The ship has five loading ports leading into the second deck. Her four side ports loading ramps are located fore and aft of the super-structure, two each on the starboard and port sides. A fifth entrance is over a ramp through the stern. The COMET has two large holds, each 130 feet long and 75 feet wide, with combined bale cubic capacity of 590,000 feet.[3]

All hatches are equipped with quick acting hydraulic hatch covers which fit flush with the deck. Each hatch cover is made in two or more sections, arranged to fold clear of the hatch opening in the open

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[2]USNS COMET (T-AK 269), "Ship's Characteristics", COMET's Characteristics Pamphlet, 1957.

[3]Ibid.

position. In the closed position, hatch covers are watertight and designed to support normal cargo loads. Figure 1 indicates the roll-on-roll-off capability and vehicle packing space utilized in handling cargo on the COMET.

The Nos. 1 and 2 holds of the COMET are loaded and discharged by conventional means. The Nos. 3 and 4 holds are equipped for roll-on-roll-off operations. There are five loading ports leading into the second deck level, two ports each on the port and starboard sides and a stern port. Each of these ports is equipped with a ramp, permitting vehicle loading and discharging by the roll-on-roll-off method. A vehicle having been driven aboard at the second deck level can be driven to any level desired by means of an internal ramp system. This ramp system also permits access to the weather deck. The ramps are arranged in such a manner that vehicles may be driven onto the weather deck from No. 3 compartment moving aft, or from No. 4 compartment moving forward. Or they may be driven from the stern ramp stright through to the forward end of No. 3 upper tween deck.

Vehicles loaded by the toll-on-roll-off method may be discharged by the roll-on-roll-off method or may be lifted off with conventional cargo gear.

In the ship's two vehicle holds which measure 75 by 130 feet, there is approximately 60,000 square

feet of parking space. This space does not include the ramp areas. Should a vehicle stall on the ramp during loading operations, electric car pullers at the head of each ramp will pull them up the 14 degree slopes.

The COMET is also equipped with portable tire pumping equipment and battery chargers. There are two elevators, located fore and aft of the midships section in holds No. 3 and No. 4, which serve vehicle-driving personnel on all levels.

When loading is completed, these drivers and their vehicles will have accomplished in a matter of hours what could have taken several days if the vehicles had been loaded by conventional means, using dockside and floating cranes at both ends of the voyage. The COMET, which is also capable of loading and discharging by conventional means, has maximum flexibility for all terminal conditions.

The COMET is operated by the Atlantic Area Command of the Navy's Military Sea Transportation Service, carrying vehicles for various branches of the Armed Forces between the United States abd bases overseas, MSTS has been evaluating the potentialities of this vessel and it appears that the COMET has established its mobilization expectations.

Although it appears that immediated success was attained with the peacetime mission of the COMET that was not the case and the following shortcoming were

noted after evaluation:

1. Regular tractors were unable to maneuver trailers on the deck.
2. Trailers were sent to depots but none informed the depots of the time limit for having them loaded and return for the next sailing.
3. There was no close coordination between the ship's moves and trailer activities at either end.

To correct this situation the U.S. Army Transportation Trailer service Agency (USATTSA), was established at the Brooklyn Army Terminal. It was given the mission of "coordinating the system of moving military cargo by means of roll-on-roll-off trailers and operating facilities in connection therewith." [4] In addition, the MSTS modified the Landing Ship Dock TAURUS and added it to the service. From the inception the two vessel fleet, plus 800 trailers of all types in the spring of 1959, things started to look up for this peacetime operation of the roll-on-roll-off concept.

Movement of supplies and equipment in cargo trailers permits complete cargo movement from origin to destination without the use of material handling or manual equipment while enroute. Levels of packaging, marking and packing supplies are reduced when shipments are made in trailers. Since the trailer provides maximum protection during movement, risk of loss due to pilferage, theft or shipping damage is materially

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[4] Colonel Ransome T. Looper, USA, "Will Sealift Go RO/RO?", Armed Forces Management, October, 1963.

reduced. Maintenance of integrity of lots and packages is assured. Checking and documenting, while enroute and at destination, is held to an absolute minimum.

The roll-on-roll-off concept has been so successful that USATTSA and MSTS now have 1,025 trailers in the fleet and three ships. The USNS TRANSGLOBE, the third ship, is a converted C-4 and was put into service in June 1962. There are two new roll-on-roll-off ships in the budget which will be constructed similarly to the COMET, but will be redesigned to allow more head space in cargo compartments due to the characteristics of new military equipment. The first of these new ships, the USNS SEALIFT (T-LSU-9) was launched on 17 April 1965. They will have the same multipurpose as the COMET, that is, the big feature of fast loading of military vehicles and incredibly short turn-around time. They will also offer a means of lifting cargo without breaking bulk, a feature which has interested private industry for some time. Another very important factor about these vessels, is their dual use--they can transport vehicles or general cargo, and the conventional cargo handling gear gives the ships everything a conventional cargo ship has.

The COMET was designed to lift one-sixth of the organic equipment of an armored division, including trucks, jeeps, tanks and gun mounts, a total of approxi-

[illegible]

mately 700 units. She is capable of rapid loading and discharging of vehicles under their own power through four side ports and one stern ramp. When loading of the ship is completed, the drivers and their trucks will have accomplished, in a matter of hours, what probably would have taken several days if the trucks had been loaded by conventional means. No dockside or floating cranes are required at either end of the voyage. All of the above mentioned features will be incorporated in the two new roll-on-roll-off ships.

The information obtained from the evaluation of the MSTS ships, involved in the toll-on-roll-off concept of ship operations, has in some cases been adopted by the shipping industry. In October 1960, private coastwise shipping got a big boost when two new vessels, MV FLORIDIAN and MV NEW YORKER, were placed in service. The two were the first roll-on-roll-off ships built for commercial operations under the United States flag. The Erie and St. Lawrence Corporation placed both ships on the New York-Jacksonville run in hopes of re-establishment of one of the coastwise routes that flourished prior to World War II.

The ships are for the coastwise trade and will carry automobiles and containerized cargo. Loading and unloading of the cargo carried on the main deck is by the roll-on-roll-off principle via a shore ramp secured

to the stern. Containers and automobiles carried on the upper deck are handled by shore-based carnes. About 20 percent of the containers are for refrigerated cargo. These vessles were designed to utilize the advantageous features of both roll-on-roll-off and lift-on-lift-off.

The unusual design feature in these two vessels are the main deck cargo hold. Each consists of a single space which extends throughout the ship's length and beam, with a depth approximately the lower hold in a normal ocean-going cargo ship. The hold is 328 feet long, 52 feet wide and 18 feet deep. It has a capacity for 139 8' x 8' x 17' containers are 32 8' x 8' x 8'6" containers. In appearance it is very much like a warehouse and provides unobstructed room for moving containers. Access to the hold is through heavy steel doors at the stern. The stern opening is 21 feet wide and 17 feet high and it is through this opening that 50 automobiles can be loaded. Containers are stowed in the main deck hold by means of fork lift trucks which place one container on top of each other. The unusual hold is what actually makes the ships either all containerized, all automobiles or a suitable combination of each.

The following are the principal characteristics

of the MV FLORIDIAN and MV NEW YORKER:[5]

1.	Length, overall	362 feet
2.	Length, B. P.	341
3.	Breadth, molded	52 feet
4.	Draft, fully loaded	14 feet 6 inches
5.	Gross registered tonnage	4,684 tons
6.	Speed	16 knots
7.	Passengers	6
8.	Crew	23
9.	Container capacity	190
10.	Auto-truck, capacity, average	50

In 1963, the State of Alaska recieved the first of three roll-on-roll-off type vessels, MV MALASPINA, that will be operating over the nearly 500 mile route between Prince Rupert, British Columbia and Haines, Alaska. The ships will be of identical design and will carry passengers and vehicles. The entire route over which they will operate is within sheltered island waters. The State of Alaska feels a great need for this type of vessel to maintain what they call the "Marine Highway"[6] of Alaska. The vessels will have capacities for 51 trailers (27 feet in length), 109 automobiles and 500 passengers. This type vessel is another application of the roll-on-roll-off concept for commercial use.

During March 1965, a new ocean-going freighter, without a single boom, derrick or crane of any kind,

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5"Roll-On/Off Containership Delivered", Marine Engineering/Log, October 1960

6"MV MALASPINA", Marine Engineering/Log, April, 1963.

entered New York Harbor and ushered in a new innovation in the shipping industry. The new innovation was in the form of Norway's DYVI ATLANTIC,[7] special automobile carrier of 2,400 deadweight tons, to be utilized between the United States and Europe.

Owned by Autoshipping Company, the A/S DYVI ATLANTIC can accommodate 1,350 European compacts or approximately 750 standard size American automobiles within her more than 1,000,000 cubic feet. Presenting an unusally flat silhouette, the 485 foot long vessel measures 65 feet from waterline to superstructure deck. Such ample freeboard affords DYVI ATLANTIC seven spacious car stowage decks, each connected to the deck above by internal ramps.

For rapid loading and unloading with minimum amount of handling, DYVI ATLANTIC utilized the roll-on-roll-off concept. Cars are driven aboard ship via a ramp linking the pier with one of DYVI ATLANTIC's eight side ports (four to a side). As soon as the car has passed through the side port, which measures an ample 9 feet 9 inches by 7 feet 3 inches, the vehicle is directed to an assigned position on a specific deck. After the longshoreman-driver positions the car in its

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[7] "New Ramp to Europe", Via Port of New York, March, 1965.

stowage spot, the vehicle is securely lashed to the deck for the long overseas voyage. Loading time for the DYVI ATLANTIC's full consignment of 1,350 compacts or 750 standard size cars in six hours and four hours, respectively. The ship has also been carefully engineered to insure the highest degree of safety and comfort during loading and unloading operations. While her primary function will be movement of automobiles between the U.S.A. and Europe, DYVI ATLANTIC can also be used efficiently for large consignments of palletized cargo which would be driven aboard or taken off by forklift trucks. Under current arrangements, DYVI ATLANTIC will carry Volkswagons on her westward transatlantic passage and pcik up American cars at Port Newark, New Jersey for her return to Europe. This new ship presents more evidence of the European interest in the commercial application of the roll-on-roll-off concept.

Any discission of the roll-on-roll-off operation must include one of the earliest commerical contribution, in this area, the seatrain. The first seatrain was put into operation between New Orleans and Havana, Cuba, in 1929. Since that time, other vessels of this type have been constructed and placed in service between New Orleans, Havana, New York and Texas City.

The seatrain vessels are ocean going steamers ranging from 450 to 478 feet in length, and have four

decks, on each of which, standard guage railroad tracks are laid. Each vessel is capable of carrying 100 loaded freight cars. The ships are loaded and discharged by means of special crane elevator equipment installed on the pier that conveys freight cars into and out of the holds of the vessles. Each car, when placed in position on the vessel is securely anchored by means of four rail clamps to prevent rolling on the tracks. Powerful jacks, operating at an angle of 45 degrees with the vertical, relieve the car springs of the weight of the car. Four stout chains and turnbuckles from the frame of the car draw it firmly down upon the jacks.

From a vessel operatings standpoint, the seatrains are efficient in that they reduce the time spent in port loading and dischraging. They also reduce general terminal expenses by eliminating all man-handling of cargo through the substitution of simple machinery to move a relatively small number of large units--the freight cars. Because of faster port dispatch, seatrains are able to spend a greater proportion of their time actually carrying revenue cargo than can other ocean-going ships. The seatrains, from the shipper's standpoint, have been of value in that they have helped to decrease, or in some cases, eliminate packing costs and have had an excellent record in delivering shipments in good condition.

The seatrain concept has not been considered entirely successful by many members of the shipping industry due to the high investment and operating cost involved. When Seatrain Lines combined the use of railroad freight cars and ships, it necessitated the building of expensive terminal facilities which had to be located at rail centers. The expensive terminals tied down to rail head centers caused many shippers to shy away from this concept of water transportation. Regardless of the costs, the Department of Defense realized the concept's potential, and so when the need arose, developed their own roll-on-roll-off operation.

CHAPTER IV

THE LIFT-ON-LIFT-OFF CONCEPT

With the advent of unitization of general or packaged cargo, the concept of containerization in the transportation industry has blossomed into a new way of life for both shippers and consumers. Many of the progressive thinking shipping companies, such as Grace Lines, Matson, Sea-Land, etc., have taken specific areas of the containerization concept and developed them for their own particular operations. Many other companies have not gone to complete containerization, but have realized that to compete successfully they must adapt to this new way of shipping cargo to some extent. The use of containerization is what gave birth to the many and varied forms of the lift-on-lift-off cargo handling operation.

Containerized cargo can be handled in most conventional type cargo vessels, to some extent or another, depending on the actual type of vessel. In conventional type vessels, there is a large percent of wasted cargo space when containers are stowed aboard. There is no real cargo handling problems since most containers have padeye arrangements on each corner so that it can be lifted using four hooks attached to the cargo hook and

whip. Some companies place small forklift trucks in a ship's hold to move the containers around once they have been lifted aboard, so that actual handling is reduced. As a general rule, most conventional type cargo vessels are carrying more containerized cargoes than they were the years ago and this seems to have come about because the consumer prefers this method of transporting cargo. The actual lift-of-lift-off operation consists of nothing more than lifting containerized cargo on or off a ship, whether it be a conventional type cargo vessel or a specially designed container ship.

The conventional type cargo vessel and the problems they faced handling containerized cargo is what caused many companies to look for more efficient methods of operation. Grace Lines, a company that operates ships in both the cargo and passenger trades, in 1960 gave containerization a new dimension by introducing the SANTA ELIANA [1] on the New York to Venezuela run. The vessel, a former C-2 that was reconstructed to a lift-on-lift-off ship, was the first all container ship to enter the overseas foreign trade of the United States. It was joined shortly after by a

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[1] "Grace Initiates Seatainer Service", Marine Engineering/Log, February 1960.

sister ship, the SANTA LEONOR.[2] The two ships offer shippers weekly sailing between New York and La Cuaira, Puerto Cabello and Maracaibo, Venezuela.

Each of the container ships can accommodate a total of 476 containers measuring 8x8x17 feet. Of these, 382 are stowed below decks and 94 are stowed on deck. The transformation of the two ships entailed major shipyard work and consisted of lengthening the ships by 45 feet and increasing the beam by 11 feet by addition of sponsons.[3]

Grace Lines dabbed its new operation as the "Seatainer" service.[4] The new ships represented an estimated outlay of $10 million. The extensive reconstruction and refitting of the two ships cost $6,931,819.[5] In addition, the line purchased 1,500 aluminum containers and also acquired a number of forklifts trucks and chassis for use at the terminals. The company was confident that the many advantages its integrated land and sea service offers its shippers, as well as the rapid turn-around time, would justify the initial expenditures.

Grace's Seatainer service offers the shipper

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[2]Ibid., p. 55

[3]Ibid.

[4]Ibid.

[5]Ibid.

door-to-door pick up and delivery. The products shipped receive the maximum protection against damage or pilferage. Consequentially burdensome claims are eliminated. Many packing costs can also be eliminated because of the protection afforded by containers. Besides putting it in a favorable position to attract cargo offerings, Grace's Seatainer service assures rapid vessel turn-around.

The SANTA ELIANA and SANTA LEONOR were converted to containerships from designs developed by George G. Sharp, Inc. This well known firm of naval architects previously designed the very successful Pan-Atlantic containerships operated by the McLean interests.[6] The reconstruction of the two ships was handled by Maryland Shipbuilding and Dry Dock Company of Baltimore. Maryland was awarded the work on the low bid price of $6,931,819.[7] This covered both ships and included the cost of installing of three gantry cranes on each ship. This same yard crrently is building two small-vessels for Containerships, Inc., also a George G. Sharp design.

It should be understood at the outset that the

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[6]Ibid., p. 56

[7]Ibid.

design of the Grace containerships was predicted on the selection of an 8x8x17 foot container size as being optimum for the intended service. This size permits one or two to be carried on standard trailer trucks and three units of this size fit on a standard 51 foot long railroad flatcar. Both modes of transportation will be used for pick-up and delivery of containers to and from terminals.

The 1,5000 containers ordered by Grace were fabricated by the Highway Trailer Company.[8] Their construction incorporates high tensile steel corner posts and high-strength aluminum body. The interior is faced with plywood, except the flooring, which is oak. The eight steel corner casting designed by National Malleable have a hot-dip aluminum coating to prevent galvanic corrosion which otherwise would occur when aluminum and steel are in contact. Each container weighs 4,234 pounds and has an inside cubic of 902 cubic feet capacity. Cargo weight capacity is 18 long tons. Slats are provided at its base to receive fork lifts.[9]

The Garce Line containerships' holds are fitted with a total of 84 vertical cells to accommodate 382

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[8] Ibid.

[9] Ibid.

of the container units below decks. The design of the Grace Line ships was based on that of the Pan-Atlantic Company's fleet of lift-on-lift-off ships that used the vertical cell arrangement in their holds. The other 94 containers are stowed on the pontoon covers on the shelter deck. The line also has developed special containers for transporting automobiles in these holds. The combined cargo capacity within the 476 containers is 549, 352 bale cubic feet. On a deadweight basis, total container capacity is 7,142 tons.[10] The designer also incorporated tanks in the new sponsons to facilitate carrying petroleum on the return trip from Venezuela, thus containerized cargo is not the only paylaod of these two ships. The main particulars of the SANTA ELIANA and SANTA LEONOR, before and after conversion, are found in Table II.

The most important advantage a container ship enjoys over its conventional counterpart is its quick turn-around time. The Grace Lines containerships have a turn-around time of approximately 11 hours and this is attributed to the rapid cargo handling system installed. Each ship is fitted with three Pacific Coast Engineering gantry cranes.[11] Two serve the con-

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[10] Ibid.

[11] Ibid., p. 57.

TABLE II

CHARACTERISTICS OF GRACE LINES CONVERSIONS**

	Original C2-S-Ajl	C3-S-45a Containership
Length, over-all, ft-in	459-1	504-1
Length, B.-P, ft	435	480
Beam, molded, ft	63	74
Depth, shelter deck, ft	40	40
Design draft, ft-in	25-9	25
Displacement, tons	13,810	15,840
Bale cubic, cu ft	542,800	442,300*
Cargo deadweight (excluding container wt), tons		7,142
KM, transverse, metacenter, ft	25.3	29.9
Block coefficient	0.68	0.62
Cargo stowage factor, cu ft/ton, @25-ft draft	....	70
Shp-normal	6,000	6,000
Speed, loaded, knots	15.5	15
No. of containers (8x8x17ft)	....	476

*within 476 containers

** Source: "Grace Initiates Seatainer Service", Marine Engineering/Log, February, 1960.

tainer cells forward of the midships house and one works the cells located aft of the house. Each crane requires only 4 minutes to complete a loading and discharge cycle. This cycle involves taking a full container from a truck on the dock, stowing it in a predetermined cell, then removing an empty container from another cell and depositing it on the truck chassis. If the operation involves only one operation, either loading or discharging, then the cycle time is only 3 minutes.

The PACECO[12] gantry cranes incorporate a number of advanced engineering features to achieve its rapid, accurate and automatic handling of the containers. The crane structure has a four-legged, wheeled base. The wheels are mounted on port and starboard tracks so as to straddle the deck and permit longitudinal positioning of the crane. Each crane is independently powered by two General Motors Diesel generator units. These units are connected in series so that if either generator unit should fail, full current and torque would still be produced and the loading operation could proceed at half the normal speed.

The crane is fitted with a telescopic girder extension with an outreach of 15 feet over the deck.

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[12]Pacific Engineering Company (PACECO)

It can serve either the port or starboard sides of the ship. This girder travels on wheels and moves inboard and outboard during each cycle of the loading operation. A traveling bridge or trolley with a operator's cab controls the hoisting and drive gear while at the same traversing the girder. Controlled from the trolley is a National Malleable[13] lifting spreader. This is a rectangular unit which engages the top of the container and then raises or lowers it as necessary.

The entire container handling crane is equipped with automatic and manual controls. In the automatic operation, all the operator has to do is to select the cell which is to be loaded or unloaded and push the appropriate button on the control console in his cab. If it were to be a loading operation the telescopic girder would move outboard. Then the traveling trolley would move out over the container and lower the lifting spreader. The latter would engage the container and it would then be lifted to the trolley. The trolley and girder would move inboard until the container was centered over the designated cell. The container would be lowered into place and the spreader would release itself. The entire foregoing operations are automatically regu-

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[13]National Malleable Company builds the lifting spreader attached to the PACECO gantry.

lated and sequenced with the push of one button. The vessels are disigned such that, threee loaded containers can be swung outboard simultaneously and the list of the ship will not exceed 6 degrees.

The type of gantry cranes found about the Grace Line ships were adapted from the successful Pan-Atlantic-McLean operations. Most fully containerized ships used a similar type gantry in their lift-on-lift-off operations since it has been found to be very successful from the point of view of loading and discharging time, good maintenance performance, and is reliable and easily operated. Further mention of this gantry crane will be forthcoming in this discussion of the Sea-Land operation.

The Grace Line management did not rest on its laurels with the operation of the first fully containerized ships in foreign service. They had George G. Sharp, Inc. design the SANTA MAGDALENA,[14] a passenger-cargo ships, for the South American trade. From the beginning the Grace Line management desired, as the major objective, to achieve increased efficiency by lowering cargo handling time and costs. An operations analysis of the trade route was made by Sharp to determine the characteristics of the cargo moving on the route and to establish

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[14] "SANTA MAGDALENA", <u>Marine Engineering/Log</u> March, 1963.

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[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

the feasibility of mechanical handling of cargo in units This operations analysis included a detailed study of the cargo commodities transported on the route and analysis of weight, dimensions, net cubic, gross cubic, port of origin, port destination and a classification of the cargo concerning its succeptibility to unitization. Trends in cargo carryings were analyzed and, it conjunction with Grace Lines economists, were projected into the future. The port conditions would have a decided effect upon the design of the cargo-handling system and the ship.

Comparisons of the cargo moving north and south were made to select the proportion of space to be adapted for containers, pallet, trays and bananas. Analyses were made of year-to-year and voyage-to-voyage variations to determine the flexibility required. The integration of the cargo requirements, along with the requirements for passengers and public spaces led to the design of the SANTA MAGDALENE and her sister ships. The ships were to contain the most varied and modern mechanical cargo-handling system to be incorporated in a ship. The systems include large overhead cranes for containers, side-porters, horizontal and vertical conveyors and elevators, each design to perform a different cargo-handling function, but all systems to work together as a single complex. The SANTA MAGDALENA and

her sister ships were built expressly for the type of cargo trade Grace Line expected on its South America routes.

The containers to be used on the SANTA MAGDALENA are stowed in holds 2 and 5, in portions of holds 3 and 4 and on deck and are handled by four "C" type gantry cranes.[15] Basically the ship is designed for 20 foot standard containers (19' 10½" long) and either 8 or 8½ feet in height. In addition, the inboard cells in holds 2 and 5 are arranged for ready adjustment for the stowage of 40 foot container capacity is as follows:[16]

1.	If all are 20 foot long	175
2.	If 20 foot below deck and 40 foot on deck	147
3.	If maximum number of 40 foot units	131

Four twenty ton capacity deck cranes are provided, two forward and two aft, to handle the containers in holds 2,3,4 and 5 and the main deck forward and aft. The cranes are of the traveling gantry type, running om crane rails located port and starboard near the ship's side. The crane consists of a "C" type gantry frame and telescopic boom assembly for obtaining the 15 foot outreach required for dockside operation with a load trolley and spreader for handling the container.

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[15]Ibid., p. 45.
[16]Ibid.

The container spread is of novel design being telescopic in itself to handle 17 foot or 20 foot containers. National Malleable Company latching devices are mounted in each corner of the container. The latching device are automatic in their latching operation, requiring only the lowering of the spreaded into contact with the container, while the unlatching is done hydraulically, on signal from the operator's cab. The two cranes forward or aft are so arranged as to provide means for their marrying to handle a single 40 foot long container. A separate spreader is provided for this purpose and is so arranged so it may be supported from the 20 foot spreader on each of the cranes.

The container lift-on-lift-off ships built by Grace Line, over the past five years, have proved to be very successful on their South American trade route. Grace was definitely the pioneer company in developing container type ships for foreign trade and they of course, based their Sharp ship designd on those utilized by the McLean Sea-Land coastwise operation.

In 1955, Malcolm McLean,[17] a young East Coast trucking operator, came up with a new concept in coastal shipping. He decided to combine the best features of

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[17]G. Cardwell, "From Clippers to Container Ships", National Defense Transportation Journal January-February.

door-to-door trucking with the economy of water transportation. Thus, McLean Industries was born and their flag raised aboard the ships that comprised the Waterman Steamship Company and the Pan Atlantic Steamship Company. McLean's idea was termed both revolutionary and ridiculous by many of the transportation experts.

McLean's initial operation conisted of two T-2 tankers operating between New York and Houston. Shoreside cranes were used to lift the truck trailers on the ships. After a year of operation that was also one of trial and error, the company converted six C2 vessels to carry 226 thirty-five foot truck trailers above and below deck. Two cranes were added on each ship's supersturcture to eliminate dependence upon land based facilties. This was the beginning of the only organization in the world combining under one management the coordinated movement of cargo via land and sea. McLean renamed his company Sea-Land and his operation has successfully reviewed intercoastal shipping in such a manner that business is being taken away from the railroads.

Spearheading this new service was the construction of the world's largest dry cargo vessel, the S.S. ELIZABETHPORT, Known as a jumbo container ship, it has the following specifications:[18]

1. Displacement tons 27,698

[18]Ibid., p. 33.

FIGURE 2

2.	Gross tons	16,395.30
3.	Net tons	12,508.64
4.	Length overall	627' 4 5/8"
5.	Breadth extreme	78' 5 3/8"
6.	Depth loaded draft	27' 1 1/8"
7.	Cruising speed	15 knots

The ELIZABETHPORT can accommodate 476 thirty five foot truck trailers, which serve as standard over-the road units. They were specially designed for automatic loading and detached from the chassis in seconds to become huge shipboard containers. The utilization of the trailers as containers, thus, eliminated the need for freight to be specially packed and crated by the shipper. The stowage arrangement for the 476 trailers is shown in Figure 2.

Each unit can carry up to a maximum of 45,000 pounds of cargo with a 2,088 cubic foot capacity. Special climate controls have been built in the trailers to provide constant temperature maintenance ranging from 0 degrees to 65 degrees F. Fifty-six refrigerated units can be handled on the main deck of the ship. These trailers have a maximum cargo carrying weight of 42,000 pounds, encompassing, 1,520 cubic feet and are capable of maintaining all temperatures from 15 degrees F. to + 60 degrees F.[19]

The containership carries a crew of 43 men plus a Master. It utilizes all of the latest navigational

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[19] Ibid.

aids. On the main deck, both fore and aft, two mooring winches with automatic tension control keep the ship breasted in at all times to facilitate cargo handling. Large pumps have been installed to enable fast ballasting for trim operation of the vessel.

After Sea-Land trailers pick up freight, the unit is sealed under the shipper's supervision. This procedure reduces the pilferage problems and cuts insurance costs. For less than truckload shipments, consolidation terminals are located in various manufacturing areas throughout the country. The trailers, then, move over the highway directly to the dockside and are parked at a marshalling area in order of loading. The trucks are driven alongside the ship, the trailers detached from the chassis and the giant containers lifted aboard.

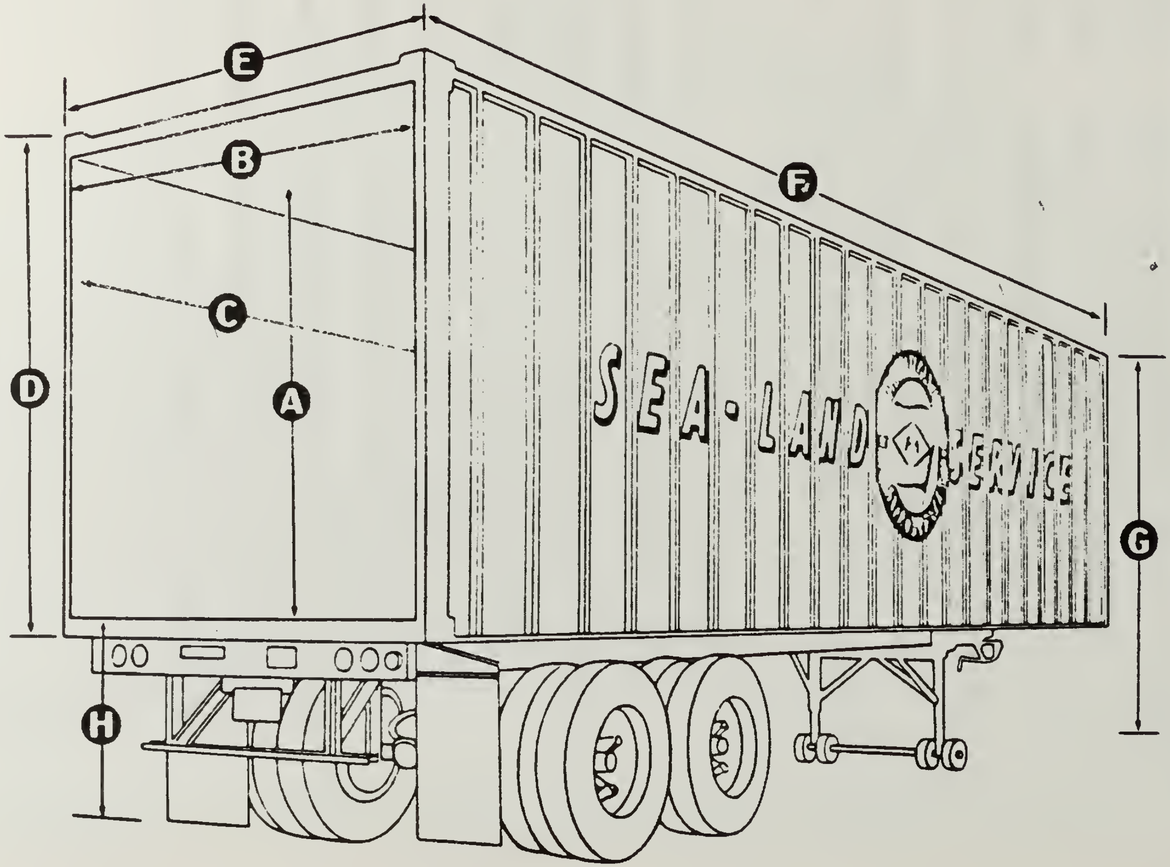
The lift-on-lift-off operation is accompolished by means of two traveling gantry cranes permanently installed on the ship. They are supported by two rails mounted on the port and starboard sides, which run the full length of the cargo cell area. Two tow winches driven by hydraulic motors that are powered by hydraulic pump units move the gantry cranes. On the bridge section of the crane are the operator's cab and the spreader bar. The spreader bar is equipped with leveling cylinders to compensate for list. Four twist locks on each corner couple the trailer to the spreader for loading or dis-

charging. The entire process of lifting a trailer ($22\frac{1}{2}$ tons of cargo) from the chassis onto the ship and placing another from the ship onto the chassis takes approximately four monutes. This loading time factor gives a Sea-Land jumbo trailership, with a capacity of 476 trailers, turn-around time of approximately 48 hours, discharging and loading better than 20,000 tons while in port.

Sea-Land operates the world's largest fleet of trailerships: six C-2 type, each carrying 226 demountable body trailers; four jumbo type, each carrying 476 demountable body trailers; one T-2 type, carrying 196 demountable body trailers, two C-4 type, carrying 166 demountable body trailers, plus 425,000 cubic feet of cargo space; one roll-on-roll-off, 313 foot trailer carrier; and one, specially designed, heavy-lift (up to 60,000 pounds) cargo vessel, the 492 foot S.S. DETROIT. Three C-2s, one jumbo, one T-2 and the DETROIT are in constant United States-Puerto Rico scheduled service. The balance of the fleet operates on regular coastwise, intercoastal and Alaskan runs. The trailership fleet is supported by 7,529 dry trailers, 788 controlled-temperature trailers, 460 open top trailers, 490 insulated trailers and 100 insulated-ventilated trailers, handling less-than-truckload and truckload freight with door-to

SEA-LAND Trailers

Specifications and Capacities



NOTE: Doors removed to show inside dimensions.

INSIDE DIMENSIONS

OPEN TOPS	
A—Height	7′ 10″
B—Width	7′ 8½″
C—Length	34′ 7¼″
Max. Cargo Weight	45,000 lbs.
Empty Weight	10,340 lbs.
Cubic Capacity	2088 Cu. Ft.
VAN	
A—Height	7′ 10½″
B—Width	7′ 8½″
C—Length	34′ 7½″
Max. Cargo Weight	45,000 lbs.
Empty Weight	10,500 lbs.
Cubic Capacity	2088 Cu. Ft.
REEFERS	
A—Height	6′ 10½″
B—Width	6′ 9″
C—Length	31′ 8″
Max. Cargo Weight	42,000 lbs.
Empty Weight	13,860 lbs.
Cubic Capacity	1520 Cu. Ft.

OUTSIDE DIMENSIONS (All Trailers)

D—Overall Height	8′ 6″
E—Overall Width	8′
F—Overall Length	35′
G—Road Height	12′ 6″
H—Tailboard Height	52″

FIGURE 3

door pickup and delivery. Figure 3 shows the standard trailers' specifications and capabilities.

As the Sea-Land operation grew, McLean divested himself of the trucking company he originally operated and concentrated on his new effort. With rapid success of the Sea-Land operation newer and larger terminals and facilities were required. At this time, there are 25 terminals and facilities in operation plus numerous representatives all over the United States and Puerto Rico. Figure 4 shows the gantry crane lifting a trailer aboard a jumbo trailership and also the marshalling terminal. The smooth and safe lift-on-lift-off operation and the terminals and facilities have reduced the original coastwise shcedule of a ship (carrying 476 trailers), departing every 14 days, down to one every 10 days.

With the four jumbo trailerships in operation, Sea-Land guarantees faster delivery service at lower rates. Sea-Land advertises as much as a 10% savings in volume freight charges and in less-than-truckload quantities, quotes savings as high as 20%. By using the trailers, the shipper reduces costs in packaging, cargo handling and pilferage plus pick-up and delivery.

The success of McLean's Sea Land in combining sea and land service has been proven to be a blending

FIGURE 4

of the best of both methods of transportation. This theory is being substantiated on a daily basis by other organizations in the industry that are utilizing similar combination operations and containerization. The Matson Navigation Company has invested over $18 million, in a three year period, to develope a containerized freight business between the West Coast and Hawaii. American President Lines has also had two new ships built in the last four years for the Far East trade that are partially containerized. The general approach of the shipping industry today is some form of a full or partially containerized vessel that will be involved in the lift-on-lift-off operation.

CHAPTER V

ANALYSIS OF ROLL-ON-ROLL-OFF VERSES

LIFT-ON-LIFT-OFF

In attempting to analyze and compare the roll-on-roll-off and lift-on-lift-off cargo handling operations from the cost point of view, certain rather arbitrary assumptions were made to simplify the problem and reduce it to a workable form. In making this analysis the ship utilizing the conventional gear was used as the common denominator since thus type pf ship is the most widely used in todays, operations. Fixed runs have been assumed between two ports, at both ends of which the ship discharges a full cargo and reloads to capacity. The ships are assumed to have the same dimensions, hull form and power plants as its conventional rival. The C-3 and C-4 Mariner class ships have been selected for this purpose since they are representative designs on which considerable data is available. The roll-on-roll-off ship and the container ship (lift-on-lift-off) are also assumed to be in service only 330 days of the year as compared to the 350 days allotted to the conventional cargo ship. The initial investment is based on new construction and the annual operating costs are relatively close (operating costs vary in different trades). The

crew sizes for each ship are assumed to be the same. The "stevedore" or "Measurement" ton, consisting of 40 cubic feet, is used rather than the deadweight ton in all cases since the great majority of items comprising a general cargo fall into that former category.

The final result of all the following studies as, summarized in Table III, is a cost comparison of shipping a ton of cargo via roll-on-roll-off and lift-on-lift-off ship types. These results are expressed in dollars and cents to illustrate the problem. However, the aim is to present qualitative, rather than quantitative results. The primary objective is to demonstrate approximately how the different ships compare, rather than to attempt to present hard and fast cost figures.

The roll-on-roll-off (trailer ship) ship is making its debut in the general cargo field and at the moment, most of the movement is confined to coastwise trade with the exception of the MSTS operations. Such a ship must, for the time being, operate under rather severe limitations. In many cases, as we have already seen, it requires special terminal facilities for trailer loading and a network of highways branching out from the port. These limitations will probably ease with time and within the foreseeable future, it appears that this type ship should replace the general cargo ship

TABLE III

Summary of cargo transportation cost studies*

Class of Ship	Description	Total Cost per Measurement Ton: On 2000 Mile Round Trip U.S.A. Coastal Run	Total Cost per Measurement Ton: On 7000 Mile Round Trip U.S.A. to a Foreign Port
C3-S-A2	Roll-on/Roll-off trailer ship	3.63	10.27
C3-S-A2	Container ship	6.17	9.08
C-4 Mariner	Conventional gear	21.40	20.20
C-4 Mariner	Roll-on/Roll-off trailer ship	3.44	9.31

*Based on a study conducted by U.S. Maritime Administration.

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on relatively short fixed runs between seaports, while the general cargo ship will continue to operate in the tramp routes.

Table IV shows the estimated weight and construction cost figures for two "C-3" class vessels; one a conventional general cargo ship and the other a roll-on-roll-off ship with a capacity for about 170 trailers. For purpose of comparison, both ships are of identical form and dimension. Although a standard "C-3" hull could be converted to trailer service, an original roll-on-roll-off ship design would in all probability result in greater beam relative to depth; a wide transom stern and other modification to facilitate the loading and stowage of trailers.

The roll-on-roll-off ship cannot make effective use of as large a percentage of the gross cargo hold volume as the general cargo ship. The bale cubic of a general cargo ship varies between 85 and 90 per cent of the molded volume. In actual practice only about 85 per cent of the bale capacity is utilized due to dunnage and broken stowage. Thus, about 75 per cent of the original molded volume is occupied by cargo. With carful design, a roll-on-roll-off ship can utilize about 40 per cent of the molded volume for cargo stowage assuming 85 per cent effective stowage.

TABLE IV

Comparative Weight, Cargo Capacity and Cost Conventional C-3 Vessel and Trailer Ship*

	Conventional C-3 Ship (Without Refrig.) 465' x 69' 6" x 42' 6"	Roll-on-Roll-Off (170 Trailer Units) 465' 69' 6" x 42' 6"
Weight (Tons)		
Main Hull Steel	3,050	2,500
Super structure	230	230
Main Hull Outfit	660	600
Living Quarters Outfit	250	250
Cargo Handling Gear	270 (10 gangs)	50 (Ramp Hoists)
Machinery 8,500 SHP	620	620
Light Ship	4,980	4,250
Displacement	14,180	9,240
Gross Deadweight	9,200	4,990
Trailer Units at 5 Tons Fuel Oil, Fresh Water, Stores, etc.	1,500	1,500
Net cargo deadweight	7,700	2,640 (170x15.5T)
Cargo Capacity		
Molded Cargo Cubic	770,000	770,000
Gross Bale Cargo Cubic	680,000	306,000 (170x180c.f.)
Actual Cargo Stowed	578,000 (75% molded)	260,000 (34% molded)
Cubic Feet per Ton (Based on Actual Cargo Stowed)	75	98.5
Measurement Tons at 40 Cu. Ft. per Ton	$\frac{578,000}{40} = 14,450$	$\frac{260,000}{40} = 6,500$
Estimated Cost	$5,750,000	$5,060,000

*Based on a study conducted by U.S. Maritime Administration

TABLE V

Comparative Cargo Transportation Cost Study Conventional C-3 vessel and Trailer Ship Based on 7000 Mile Round Trip to a Foreign Port*

	Conventional C-3 Cargo Ship	Roll-on-Roll-off Ship 170 Trailers Capacity
Initial Cost	$5,750,000	$5,060,000
Number of Crew	50	50
Operating Cost per Year:		
Crew Wages and Subsistence	$ 344,000	$ 344,000
Voyage Repairs	86,000	76,000
Stores and Supplies	63,000	63,000
Insurance (Total 3%)	173,000	152,000
Fuel Oil at $2.25 per bbl.	192,000	302,000
Harbor Fees and Misc.	57,000	111,000
Pier or Terminal Rental	200,000	150,000
Administration	100,000	100,000
Amortization (4%, 20 years)	423,000	372,000
Total Operating Cost per Year	$1,638,000	$1,670,000
Round Trip Distance-Miles	7,000	7,000
Speed of Vessel-Knots	16	16.5
Round Trip Sea Time-Days	18.2	17.7
Round Trip Port Time-Days	20	2.0
Total Round Trip Time-Days	38.2	19.7
Days in Service per Year	350	330
Round Trips per Year	9.16	16.8
Measurement Tons Cargo/Trip (each Way)	14,450	6,500
Measurement Tons of Cargo per Year	265,000	218,000
Ship Operating Coast per Ton	$ 6.17	$ 7.65
Cargo Handling per Ton in U.S.A. **	8.50	.06
Cargo Handling per Ton Elsewhere**	5.00	.04
Ship plus Stevedore Cost per Ton	$ 19,67	$ 7.75

*Based on study conducted by the Maritime Administration
** Average total of cargo handling on ship plus

continued

TABLE V, continued

	Conventional C-3 Cargo Ship	Roll-on-Roll-off Ship 170 Trailers Capacity
Annual Trailer and Tractor Expenses:		
Trailer Rental & Exp. ($8.00/D/Trailer)		
$8.00x170x330 — $450,000		
Trailer & Cargo Ins. ($1.35/D/Trailer)		
$1.35x170x330 — 76,000		
Amortization & Maint. Of 12 Tractors at Terminals — 22,000		
Total — $548,000		
Trailer and Tractor Expenses per Ton	———	2.52
Total Cost per Measurement Ton	$ 19.67	$ 10.27
(Terminal to Terminal)		

TABLE VI

Comparative Cargo Transportation Cost Study Conventional C-3 Vessel and Trailership Based on 2000 Mile Round Trip Coastal Run*

	Conventional C-3 Cargo Ship	Roll-on-Roll-off Ship 170 Trailers Capacity
Initial Cost	$5,750,000	$5,060,000
Number of Crew	50	50
Operating Cost per Year:		
Fuel Oil at $2.25 per bbl.	$ 104,000	$ 210,000
Other Items Similar to Table 5	1,446,000	1,368,000
Total Operating cost per Year	$1,550,000	$1,578,000
Round Trip Distance-Miles	2,000	2,000
Speed of Vessel-Knots	16	16.5
Round Trip Sea Time-Days	5.2	5.1
Round Trip Port Time-Days	20.0	2.0
Total Round Trip Time-Days	25.2	7.1
Days in Service per Year	350	330
Round Trips per Year	13.9	46.5
Measurement Tons Cargo/Trip (each way)	14,450	6,500
Measurement Tons of Cargo per Year	402,000	605,000
Ship Operating Cost per Ton	$ 3.85	$ 2.6
Cargo Handling per Ton in U.S.A. at both Terminals-$8.50x2**	17.00	.12
Ship plus Stevedore Cost per Ton	$ 20.85	2.72
Annual Trailer and Tractor Expenses: (See Table V $548,000		
Trailer and Tractor Expenses per ton	———	.91
Total Cost per Measurement Ton (Terminal to Terminal	$ 20.85	3.63

*Based on a study conducted by the U. S. Maritime Administration

** Average total of cargo handling on ship plus terminal handling.

within the trailer itself. For two ships of identical dimensions and form, the general cargo ship will carry roughly twice the volume of cargo per voyage (see Tables V and VIII).

The chort port time tends to cancel out this deficiency in cargo capacity. Table V indicates that two ships of the C-3 class would transport nearly equal measurement tonnage of cargo per year on a 7,000 mile round trip route. As the length of the run is reduced the port time becomes a larger percentage of the total round trip and the roll-on-roll-off ship shows up to progressively greater advantages, as illistrated in Table VI, for a 2,000 mile round trip coastal run on which she would carry about 50 per cent more annually.

Table VII gives a comparative estimate of weights and construction costs for two ships of the C-4 Mariner class. In this case the roll-on-roll-off ship would have a capacity of approximately 210 average size trailers. It should be noted that the Mariner is somewhat better adapted to trailer service than the C-3, using about 37% of its molded volume as compared to 34% for the latter.

Comparative cost of cargo handling per ton on a 7,000 mile route are shown in Table V and VIII for the C-3 and Mariner, respectfively. The C-3 has a slight

TABLE VII

Comparative Weight, Cargo Capacity and Cost Conventional
C-4 Mariner Vessel and Trailership*

	Conventional C-4 Mariner Cargo Ship (W/) Refrig.) 528'x76'x44'6"	Roll-on-Roll-off (210 Trailer Units) 528'x76'x44'6"
Weight (Tons		
Main Hull Steel	4,150	3,500
Superstructure	360	360
Main Hull Outfit	1,270	1,200
Living Quarters Outfit	400	400
Cargo Handling Gear	400	75 (Ramp Hosits)
Machinery 17,500 SHP	1,095	1,095
Light Ship	7,675	6,630
Displacement	18,525	13,290
Gross Deadweight	10,850	6,450
Trailer Units at 5 tons		1,050
Fuel Oil, Fresh Water, Stores, Crew, etc.	2,150	2,150
Net Cargo Deadweight	8.700	3,250 (210x15.5T)
Cargo Capacity		
Molded Cargo Cubic	870,000	870,000
Gross Bale Cargo Cubic	767,000	378,000 (210x1800 c.f)
Actual Cargo Stowed	652,00(75% Molded)	321,000 (37% Molded)
Cubic Feet per Ton (Based on Actual Cargo Stowed)	75	98.5
Measurement Tons at 40 Cu. Ft. per Ton	$\frac{652,000}{40}$ = 16,300	$\frac{321,000}{40}$ = 8,020
Estimated Cost	$8,764,000	$7,800,000

*Based on a study conducted by the U.S. Maritime Administration.

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TABLE VIII

Comparative Cargo Trabsportation Cost Study Conventional C-4 Mariner Vessel and Trailership Based on 7000 Mile Round Trip to a Foreign Port*

	Conventional C-4 Mariner Cargo Ship	Roll-on-Roll-off Ship 210 Trailers Capacity
Initial Cost	$8,764,000	$7,800,000
Number of Crew	58	58
Operating Cost per Year:		
Crew Wages and Subsistence	$ 428,000	$ 428,000
Voyage Repairs	130,000	115,000
Stores, Supplies and Maintenance	73,000	73,000
Insurance (Total 3%)	263,000	234,000
Fuel Oil at $2.25 per bbl.	311,000	457,000
Harbor Fees and Misc.	67,000	143,000
Pier or Terminal Rental	200,000	150,000
Administration	100,000	100,000
Amortization (4%, 20Years)	645,000	573,000
Total Operating Cost per Year	$2,217,000	$2,315,000
Round Trip Distance-Miles	7,000	7,000
Speed of Vessel-Knots	20.0	20.5
Round Trip Sea Time-Days	14.6	14.3
Round Trip Port Time-Days	20	2
Total Round Trip Time-Days	34.6	16.3
Days in Service per Year	350	330
Round Trips per year	10.1	20.2
Measurement Tons Cargo/Trip (each way)	16,300	8,020
Measurement Tons of Cargo per Year	330,000	324,000
Ship Operating Cost per Ton	$ 6.70	$ 7.14
Cargo Handling per Ton in U.S.A. **	8.50	.06
Cargo Handling per Ton Elsewhere**	5.00	.04
Ship plus Stevedore Cost per Ton	$ 20.00	$ 7.24

*Based on a study conducted by the U. S. Maritime Administration.
**Average total of cargo handling on ship plus terminal handling.

TABLE VIII
Continued

		Conventional C-4 Mariner Cargo Ship	Roll-on-Roll-off Ship 210 Trailers Capacity
Annual Trailer and Tractor Expenses:			
Trailer Rental & Exp. ($8.00/D/Trailer)			
$8.00x210x330	$555,000		
Trailer & Cargo Ins. ($1.35/D/Trailer)			
$1,35x210x330	94,000		
Amortization & Maint. of 12 Tractors at Terminals	22,000		
Total	$671,000		
Trailer and Tractor Expenses per Ton		———	$ 2.07
Total Cost per Measurement Ton (Terminal to Terminal)		$ 20.20	$ 9.31

TABLE IX

Comparative Cargo Transportation Cost Study Conventional C-4 Mariner Vessel and Trailership based on 2000 Mile Round Trip Coastal Run*

	Conventional C-4 Mariner Cargo Ship	Roll-on-roll-off Ship 210 Trailers Capacity
Initial Cost	$8,764,000	$7,800,000
Number of Crew	58	58
Operating Cost per Year:		
Fuel Oil at $2.25 per bbl.	$ 168,000	$ 360,000
Other Items similar to Table VIII	$1,906,000	$1,858,000
Total Operating Cost per Year	$2,074,000	$2,218,000
Round Trip Distance-Miles	2,000	2,000
Speed of Vessel-Knots	20.0	20.5
Round Trip Sea Time- Days	4.2	4.1
Round Trip Port Time-Days	20.0	2.0
Total Round Trip Time-Days	24.2	6.1
Days in Service per Year	350	330
Round Trips per Year	14.5	54.0
Measurement Tons Cargo/Trip (each way)	16,300	8,020
Measurement Tons of Cargo per Year	472,000	867,000
Ship Operating Cost per Ton	$ 4.40	$ 2.55
Cargo Handling per Ton in U.S.A. at both Terminals ($8.5-x2)**	17.00	.12
Ship plus Stevedore Cost per Ton	$ 21.40	$ 2.67
Annual Trailer and TractorExpenses; (See Table VIII)	$671,000	
Trailer and Tractor Expenses per ton		.77
Total Cost per Measurement Ton	21.40	$ 3.44

*Based on a study conducted by the U.S. Maritime Administration.
**Total of cargo handling on ship plus terminal handling.

advantage over the Mariner as a conventional ship on this route due to lower operating costs relative to its cargo capacity. However, the reverse is true for the trailer ships, in which case the proportionally greater trailer capacity of the Mariner becomes a dominant factor. Both trailer ships handle cargo on this route at about one-half the cost of their conventional counterparts.

Tables VI and IX present cost figures for the C-3 and Mariner on a 2,000 mile coastal route. The cost per ton for corresponding type ships are nearly equal. Both trailer ships are able to transport cargo for about one-sixth the cost of the conventional ships due to the reduced length of voyage, which places greater emphasis on port time. The cost per ton of cargo handling for the roll-on-roll-off ship is derived from the fact that a trailer can be moved on and off the ship at an average cost of about $2.25. Assuming approximately 38 measurement tons of cargo per trailer, the total cargo handling cost for any United States port works out to be about 6 cents per ton and approximately 4 cents in a foreign port. Terminal handling of cargo is eliminated. The two conventional ships would require an average time of approximately 10 days in each port to discharge a full cargo and then reload to capacity. The roll-on-roll-off ships are able to discharge and reload in 6 or 8 hours. These factors weigh so heavily

in favor of the roll-on-roll-off ship that there can be little doubt that it will soon dominate the general cargo field on coastal runs and also offer some stiff competition on routes to the larger foreign ports.

The lift-on-lift-off operation has great potentialities in the general cargo field. As has been noted the operation has much in common with the roll-on-roll-off ship. The cargo is handled in prepacked containers, thus, eliminating considerable handling of individual units. This method has been practiced for some years on general cargo ships, using the ship's booms to hoist the containers in or out of the hold. However, the problem of shifting the containers from the hatch square out to the wings or ends of the hold still remains and thus leaves much to be desired. To overcome this limitation, we have seen that the container type ships have, in most cases, used some form of a mechanical elevator.

In making an analysis of the lift-on-lift-off operation, certain assumptions were made. First of all, the container ship is one without any conventional cargo handling gear, The containers are carried on and off the ship and stowed by tractors specially designed to handle three containers at a time. The tractors carry the containers aboard through side ports on the upper tween deck level and are tkaen to the lower decks on

elevators. The containers are set directly in place by the tractors where they are automatically secured by their short legs which engage deck sockets. The container ships discussed in this analysis do not have any of the specialized feature discussed earlier, instead they are the type ships that would handle the standard sized containers, (8'x8'x8').

Table X gives estimated weight and cost figures for a conventional C-3 class cargo ship as compared to a container ship of the same size. The only major difference between the two ships is found in the cargo handling equipment. In the container ship, there are two large elevators, one forward and one aft of the engine room. The tractors and containers are considered to be shore equipment rather than a part of the light ship weight. The tractors could, if desired, be carried aboard ship from port to port. In any event, the cost of these items must be included when estimating the unit cargo handling cost (Tables XI and XII). Three tractors are provided to serve the ship in each port. Thus, six tractors are considered in these studies for runs between two fixed ports.

It is estimated that approximately 950 containers measuring 8 feet in length, width and height could be stowed on the container ship. Assuming a stowage factor of 85 per cent within each container, the actual

TABLE X

Comparative Weight, Cargo Capacity and Cost Conventional C-3 Vessel and Container Ship*

	Conventional C-3 Ship (Without Refrig) 465'x69'6"x42'6"		Container Ship 950 Container Units 465'x69'6"x42'6"	
Weight (Tons)				
Main Hull Steel	3,050		3,050	
Superstructure Steel	230		230	
Main Hull Outfit	660		660	
Living Quarters Outfit	250		250	
Cargo Handling Gear	270	(10 gangs)	50	(Elevators
Machinery 8,500 SHP	620		620	
Light Ship	4,980		4,860	
Displacement	14,180		12,910	
Gross Deadweight	9,200		8,050	
Container Units at 1 Ton			950	
Fuel Oil, Fresh water, Stores, etc.	1,500		1,500	
Net Cargo Deadweight	7,700		5,600	1.12 x 1.5% = 107
Cargo Capacity				
Molded Cargo Cubic	770,000		770,000	
Gross Bale Cargo Cubic	680,000		487,000	(950x510 c.f.)
Actual Cargo Stowed	578,000	(75% Molded)	420,000	(58% Molded)
			.36	
Cubic Feet per Ton (Based on Actual Cargo Stowed	75		75	
Measurement Tons at 40 Cu.Ft. per Ton	$\frac{578,000}{40}$	= 14,450	$\frac{420,000}{40}$	= 10,500
Estimated Cost	$5,750,000		$5,600,000	

*Based on a study conducted by the U.S. Maritime Administration.

TABLE XI

Comparative Cargo Transportation Cost Study Conventional C-3 and Container Ship Based on 7,000 Mile Round Trip to a Foreign Port*

	Conventional C-3 Cargo Ship	Container Ship 950 Container Units
Initial Cost	$5,750,000	$5,600,000
Number of Vrew	50	50
Operating Cost per Year:		
Crew Wages and Subsistence	$ 344,000	$ 344,000
Voyage Repairs	86,000	84,000
Stores, Supplies and Maintenance	63,000	63,000
Insurance (Total 3%)	173.000	168,000
Fuel Oil at $2.25 per bbl.	192,000	274,000
Harbor Fees and Misc.	57,000	103,000
Pier or Terminal Rental	200,000	200,000
Administration	100,000	100,000
Amortization (4%, 20 Years)	423,000	412,000
Total Operating Cost per Year	$1,638,000	$1,748,000
Round Trip Distabce-Miles	7,000	7,000
Speed of Vessel-Knots	16	16
Round Trip Sea Time- Days	18.2	18.2
Round Trip Port Time-Days	20	3
Total Round Trip Time-Days	38.2	21.2
Days in Service per Year	350	330
Round Trips per Year	9.16	15
Measurement Tons Cargo/Trip (each way)	14,450	10,550
Measurement Tons of Cargo Per Year	265,000	327,000
Ship Operating Cost per Ton	$ 6.17	$ 5.35
Cargo Handling per Ton in USA**	8.50	1.98
Cargo Handling per Ton Elsewhere**	5.00	1.15
Ship plus Stevedore Cost per Ton	$ 19.67	$ 8.48

* Based on a study conducted by the U.S. Maritime Administration.
**Average total of cargo handling on ship plus loading or unloading containers at terminal.

continued

TABLE XI Continued

	Conventional C-3 Cargo Ship	Container Ship 950 Container Units
Investment in Containers and Tractors:		
Six Tractors @$25,000 — $ 150,000		
950 Containers on Ship — $ 475,000		
1900 Containers on Shore — $ 950,000		
$1,575,000		
Amortization (4%, 10 years) $194,000		
Amortization per Measurement Ton (Terminal to Terminal)	$ ______	$ .60 9.80

TABLE XII

Comparative Cargo Transportation Cost Study Conventional C-3 Vessel and Container Ship Based on 2,000 Mile Round Trip Coastal Run*

	Conventional C-3 Cargo Ship	Container Ship 950 Container Units
Initial Cost	$5,750,000	$5,600,000
Number of Crew	50	50
Operating Cost per Year:		
Fuel Oil at $2.25 per bbl.	$ 104,000	$ 200,000
Other Items Similar to Table XI	$1,446,000	$1,474,000
Total Operating Cost per Year	$1,550,000	$1,674,000
Round Trip Distance-Miles	2,000	2,000
Speed of Vessel-Knots	16.0	16.0
Round Trip Sea Time-Days	5.2	5.2
Round Trip Port Time-Days	20.0	3.0
Total Round Trip Time-Days	25.2	8.2
Days in Service per Year	350	330
Round Trips per Year	13.9	40.2
Measurement Tons Cargo/Trip (each way)	14,450	10,500
Measurement Tons of Cargo per year	402,000	844,000
Ship Operating Cost per Ton	$ 3.85	$ 1.98
Cargo Handling per Ton in U.S.A. at both Terminals	17.00	3.96
Ship plus Stevedore Cost Per Ton	$ 20.85	$ 5.94
Investment in Containers and Tractors:		
See Table XI $1,575,000		
Amortization (4%, 10 years) 194,000		
Amoritization per Measurement Ton	___	.23
Total Cost per Measurement Ton (Terminal to Terminal)	$ 20.85	$ 6.17

*Based on a study conducted by U.S. Maritime Administration

volume of cargo stowed would be in the order of 420,000 cubic feet, or about 55 per cent of the molded hold volume. This figure is to be compared with 75 per cent of the molded volume utilized by the conventional general cargo ship. Similarly, the "measurement" ton, computed at 40 cubic feet per ton, are about 14,450 for the general cargo ship and 10,500 for the container ship.

The round trip port time required to handle cargo on the container ship is estimated to be about three days as compared to approximately 20 days for the general cargo ship (see Table VIII and XIII). The average total cost of packing cargo into the containers on the piers plus carrying the loaded containers aboard ship is estimated in Table XIV to be about \$1.98 per measurement ton as compared to \$8.50 for the general cargo ship in a typical American East Coast port. The combined effect of these factors, as shown in Table XI, indicates that the container ship would handle cargo at about one-half the cost of a general cargo ship on a 7,000 mile round trip trade route to a foreign port. On a 2,000 mile round trip coastal run, the container ship would handle cargo at about one-third the cost for the general cargo ship as shown in Table XII.

From the above discussion it will be noted that the container ship and the trailer ship are about on equal footing on the 7,000 mile run, but the container

ship is not as efficient as the roll-on-roll-off ship on a short run. The decreased port time, together with lower cargo handling cost, more than compensates for the trailer and tractor expense in the roll-on-roll-off ship type operation.

The container ship presents a number of operating problems which tend to limit its use in the general cargo field. The type of cargo which can be efficiently packed into a container consists of relatively small units, such as a carton of canned goods, etc. In the studies shown in Tables XI and XII, a fixed run between two ports was assumed, requiring three ship loads of containers, to avoid delaying the ship while they are being unpacked and repacked. For ultimate efficiency, an elaborate distribution system is needed in all ports to deliver and return loaded containers to each customer's plant or warehouse. This requirement, for at least three ship loads of containers for an efficient turn-around operation, introduces a very high initial investment cost with each container type ship. Tables XII and XIII show the approximate handling time and cost for a container ship.

A comparison of the initial costs for building a C-3 type hulled conventional, roll-on-roll-off and container ship is made in Tables V and XI. It can be seen from these tables that the roll-on-roll-off has a

TABLE XIII

Cargo Handling Time Study Container Ship*

950 Containers aboard ship handled by three tractors, each capable of carrying three containers simultaneously.

Trips per Tractor to load ship	$\frac{950}{3 \times 3}$	106
Trips per Tractor to unload ship	$\frac{950}{3 \times 3}$	106
Trips per Tractor, each port		212

Average travel distance of Tractor from pier loading point to ship loading point and return is 1300 feet.

		Minutes
Tractor in transit at 5 mph	$\frac{1300}{400}$	3.0
Round trip time on elevators		2.0
Picking up and setting load in place		2.0
Dealy		2.0
Average Time per Tractor Trip		8.0
		Hours
Cargo handling time, each port	$\frac{212 \times 8}{60}$	28
Mooring ship and adjusting loading ramps		4
Total Time per Port		32
Round Trip port time	$\frac{32 \times 2}{24}$	2,7 days
Assumed Time		3.0 days

*Based on a study conducted by the U.S. Maritime Administration.

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TABLE XIV

Cargo Handling Cost Study Container Ship*

		Manhours
Three Tractor Drivers	2 x 36 hours	72
Two Elevator Operators	2 x 36 hours	72
Adjusting Loading Ramps	6 men and 4 hours	24
Packing Cargo in Containers on Pier**	950 x 4.2 Manhours	4,000
Margin 25%, for Delays, etc.		1,042
Total per Port		5,210
Stevedore Cost per Shipload of Cargo	5,210 x $4.00	$20,800
Stevedore Cost per Measure-	$\frac{\$20,800}{10,500}$	$ 1.98
Estimated Cost per Ton in Foreign Port		$ 1.15

*Based on a study conducted by the U.S. Maritime Administration.

**Based on data supplied by Dravo Corp.

definite saving in initial cost over the conventional and container type ships. Table VIII indicates that the roll-on-roll-off type ship has a cheaper initial cost than the conventional type vessel. Initial cost is a definite factor to be considered when a decision must be made as to which type of ship to use.

On these counts, the roll-on-roll-off ship has certain advantages. Trailers or vans can accomodate larger units of cargo and are more flexible from the distribution standpoint, in that they are self-propelled units capable of delivering or picking up cargo at any number of points on shore. They also have the great advantage of already exisiting in large numbers in the areas surrounding most large seaports, whereas a steel container is a rather specialized unit not in general use outside the shipping industry.

Previous discussion has pointed that the lift-on lift-off operation involving the container type ships have, in fact, increased the size of the containers and made them such that they can be placed on a trailer truck chassis and driven from point to point. This was done to overcome the above mentioned disadvantages, and companies, such as Sea-Land, Matson, and Grace Line have successfully applied this variation so the lift-on-lift-off can comparably complete with roll-on-roll-off type operations.

CHAPTER VI

CONCLUSIONS

Based on the information available concerning the roll-on-roll-off and lift-on-lift-off cargo handling operations, a valid conclusion can only be made after consideration has been give to the objectives of the type of shipping transportation service required. First of all, we have seen that the military objectives in the use of water transportation are different from those used by commercial shipping companies. The military's objective is basically one of supporting, with armored and motorized transportation, a division or such that has been placed ashore in an assualt area. That is, they require the movement of heavy vehicles that can be loaded or unloaded in relatively short periods of time under battle conditions. The meeting of this condition is not of required of commercial companies, instead they must meet the objective of moving cargo rapidly, efficiently and at low coast to be competitive with the other various modes of transportation. Commercial shipping companies are also working on the motive of profit maximization, whereas, the military is only concerned with intial and operating costs.

The roll-on-roll-off operation is better suited for military use since it assists in meeting the objective of transporting heavy vehicles for support of a division or such. Costs (initial and operating) are a consideration but not necessarily the most important one in a final decision as to which type of operation to be used. Turn-around time is a prime consideration for the military also the number of vehicles that can be transported.

Commercial shipping companies have found that it is uneconomical to use the roll-on-roll-off type operation since it does not make effective use of gross cargo hold volume as the ships used in the lift-on-lift-off operation. As was seen from the various tables introduced previously, the roll-on-roll-off operation can utilize only 40 per cent of molded volume for cargo stowage due to wasted overhead space and stowage arrangements even if the trailers are 85 per cent effectively stowed.

Both types of operation have reduced pilferage, cargo handling and packaging costs. The roll-on-roll-off operation has the superior turn-around time (6 to 8 hours versus 30 to 48 hours) which means much shorter in port time. This advantage, according to commercial companies, is off set by the superior cargo carrying capacity of most ships used in the lift-on-lift-off operation. The shippers have shown a definite liking for the

advantages of the pick-up and delivery aspects of the trailers utilized by Sea-Land, Grace Line and Matson Steamship Company, where they can load and unload the trailers themselves. The lift-on-lift-off type container ships are designed using a "cellular" method so that container stowage space can be effectively utilized. The jumbo container ship of Sea-Land can carry 22 tons of cargo per trailer. If the chassis and cabs were driven on board the ship a large amount of valuable paying cargo space would be lost.

The tables in Chapter V show that the roll-on-roll-off operation is more efficient for shorter trips because of turn-around time. It was also shown previously that most of the shipping routes serviced by commercial companies have been long runs, such as from New York to South America or New York to San Francisco. The lift-on-lift-off operation has proved successful on runs of this type because of the higher cargo load and relative short turn-around times compared to a conventional cargo vessel. Because of the above mentioned features and in conjunction with the previous discussion of the lift-on-lift-off operation, commercial companies for the long run view consider this method more economical.

The argument of high initial investment costs of the container ship versus the roll-on-roll-off counter-

part is valid. For the container ship operation to be successful and efficient, it requires a minimum of three ship loads of containers but the requirement is not so high with the trailer operation since they are easily moved at the terminals. Both operations require a heavy investment in terminal facilities. This would be required regardless of the type of operation.

Since the objectives of the shipping transportation service are very important, it is necessary to consider the type of operation and service to be used when discussing comparisons of the two operations. At this time the lift-on-lift-off method of shipping cargo is considered by commercial shipping companies to be the most successful, efficeient and economical. The design of the ships for this type of operation has considered all of the necessary aspects to make it successful if used efficiently.

The military on the other hand, did not concern themselves greatly with cost. They stated what was needed to give the necessary logistical support to an assault division of such and a ship designed to fulfill this mission. The military is so satisfied with the roll-on-roll-off operation and the ship built to utilize it, that more are being constructed and appropriated.

The analysis shows that in many areas combinations

of both the roll-on-roll-off and lift-on-lift-off operations have been utilized by both military and commercial shipping companies. Further analysis shows that these operations are all an important facts of the containerization era of transportation.

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